MAXIMUM-MINIMUM TEMPERATURES AS A BASIS FOR EVALUATING THERMOPERIODIC RESPONSE [1]

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ABSTRACT

Since hourly temperatures are not commonly recorded at many locations, a procedure is tested involving the use of daily maximum-minimum temperatures in estimating the number of hours per day above certain temperature thresholds. The procedure assumes that the daily temperature curve may be approximated by a triangle. The number of hours per day, X, above base temperature, b, is estimated as:

$$X=\frac{24\ (\text{Max}-b)}{\text{Max}-\text{Min}}$$

Correlation-regression analyses of data from five diverse locations show close relationship between actual and estimated hours. Results indicate that simple computations involving only daily maximum-minimum temperatures may be used for evaluating thermoperiodic response when variations in temperature exposure of less than 2.5 hours per day are not critical.

1. INTRODUCTION

Knowledge of the number of hours per day when the air temperature is above or below certain thresholds is useful in evaluating a season or region relative to thermoperiodic responses of plants [9], for example, the color of maturing tomato fruit. Development of lycopene, the red pigment, is closely related to the duration of temperature below 86° and/or above 50° F. [5], [6], [7]. Such temperature data are also useful to animal scientists. For example, research indicates that the heat regulating mechanism of certain breeds of cattle begins to fail about 80° F. [2]. Milk production in dairy cows seems to be more closely related to the number of hours per day above 80° F. than to maximum temperature [3].

Since hourly temperatures are not commonly recorded at many locations, the use of daily maximum and minimum temperatures in estimating the number of hours above certain thresholds was investigated. The daily temperature curve may be closely approximated by a sine function. Of course, latitude, time of year, and other factors associated with the solar climate are involved. In addition, clouds and winds, which import cooler or warmer air, may temporarily modify the normal shape of the curve.

However, in consideration of the difficulty of obtaining precise information concerning solar heat flux and because of the simplicity of a less complex computation, it was assumed that the daily temperature curve may be approximated by a triangle (fig. 1). With this assumption, the number of hours, X, above base temperature, b, was estimated as: [2]

$$\frac{X}{(\text{Max}-b)}=\frac{24}{R} \text{ or } X=\frac{24\ (\text{Max}-b)}{R}.$$

The number of hours, Y, below base, b, would be:

$$Y=24-X.$$

Lindsey and Newman [4] and Arnold [1] have discussed maximum and minimum temperatures as used in computing heat units, but an estimation of the number of hours above temperature thresholds was not investigated.

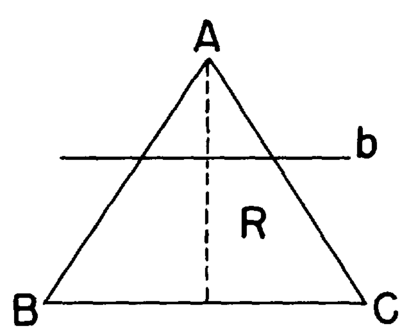

FIGURE 1.—Triangle approximating daily temperature curve. Apex A is average daily maximum temperature; the base B–C is a 24-hr. period between successive average daily minimum temperatures and the altitude R is the daily temperature range.

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[2] b must be $\geq$ minimum. When $b >$ maximum, it is obvious that $X=0$, and $Y=24$.

2. TEST OF PROCEDURE

The procedure was tested on hourly temperatures collected in 1964 at Miami, Fla.; Brownsville, Tex.; Indianapolis, Ind.; Scottsbluff, Nebr.; and Elko, Nev. [8]. One complete year of data was used from Miami, Brownsville, and Indianapolis. For Scottsbluff and Elko the periods of record were respectively, April 1–October 31 and January 1–November 8. These locations were chosen because of differences in daily temperature range which average 11°, 16°, 20°, 31°, and 42° F. respectively during July.

Six different temperatures (32°, 40°, 50°, 60°, 70°, and 80° F.) were used as base values. A computer program was used to count the actual number of hours per day above these values and to estimate the number of hours from the equation previously described. Actual and estimated hours were statistically analyzed by correlation and regression procedures.

3. RESULTS

Correlation coefficients between actual and estimated hours were above 0.98 for all locations. Regression coefficients and standard errors of estimate between actual and estimated hours are presented in table 1. The number of pairs of observations for each location and temperature is also shown. Standard errors ranged from 1.35 hr. for the 80° F. threshold at Elko to 3.27 hr. for 60° F. at Brownsville. The standard error over all locations and temperatures was 2.52 hr. Regression coefficients indicate a bias of underestimating at certain thresholds and locations. This situation tended to occur when the daily maximum was close to the threshold of interest.

These data indicate that simple computations involving only daily maximum and minimum temperatures may be used for evaluating a season or region for thermoperiodic plant response when variation in temperature exposure of less than 2.5 hr. per day is not critical. Close similarities in standard errors indicate that the use of such data ir comparative studies between different locations or times of year at a particular location is valid.

TABLE 1.—*Regression coefficients and standard errors of estimate between actual and estimated hours above selected temperature thresholds*

Location	Temperature threshold (°*F.*) 32	40	50	60	70	80	All temperatures	Pairs of observations*
			Regression coefficients					
Miami, Fla.				1.08	1.00	1.02	0.95	404
Brownsville, Tex.		0.75	0.93	0.95	1.03	1.09	1.02	508
Indianapolis, Ind.	0.98	1.03	1.02	1.01	1.11	1.08	0.98	666
Scottsbluff, Nebr.	0.81	0.86	1.03	1.10	1.14	1.19	1.02	598
Elko, Nev.	1.01	1.00	0.98	1.01	1.06	0.89	0.95	839
All locations	1.01	1.01	1.00	1.03	1.07	1.10	0.98	
Pairs of observations*	240	317	461	481	674	742		3,015
			Standard errors of estimate					
Miami, Fla.				2.59	2.75	2.72	2.73	
Brownsville, Tex.		1.53	2.68	3.27	2.94	2.29	2.76	
Indianapolis, Ind.	3.05	3.01	2.59	2.64	2.41	2.18	2.70	
Scottsbluff, Nebr.	1.61	2.28	2.06	2.31	2.06	1.61	2.23	
Elko, Nev.	2.32	2.00	1.86	1.74	1.45	1.35	2.15	
All locations	2.61	2.49	2.20	2.48	2.45	2.45	2.52	

*Cumulative for all cases when $b \geq$ minimum and $<$ maximum.

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